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## Radiation and Human Health

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### Key Facts

■ Scientists have studied the effects of radiation for more than 100 years and know how to detect, monitor and control even the smallest amounts. In fact, more is known about the health effects of radiation than most other physical or chemical agents.

■ Radiation is part of nature. Natural sources of radiation—from radon in the air, from rocks and soil in the Earth's crust and from outer space—account for 82 percent of the radiation to which the public is exposed every year. There is no evidence of any increase in cancer among people living in areas where natural, background radiation is several times higher than average—such as Han, China; Kerala, India; or Araxa-Tapira, Brazil.

■ Radiation also can be made by man. This includes hundreds of beneficial uses, including radiation from X-rays, nuclear medicine, pharmaceuticals, television sets and nuclear power plants. Man-made radiation accounts for 18 percent of the public's exposure every year. Its effect on humans is no different from that of natural background radiation.

■ Unlike nature's radiation, however, the use and handling of man-made radiation is strictly controlled and regulated. Most of the public's exposure to man-made radiation comes from medical applications.

■ People living near a nuclear power plant are exposed to only a tiny amount of radiation. Less than 1 percent of the average person's total exposure comes from nuclear power plants—about the same as watching television.

■ A 1990 National Cancer Institute (NCI) study found no evidence of any increase in cancer mortality—including childhood leukemia—among residents of 107 counties that host, or are adjacent to, 62 nuclear facilities in the United States. The conclusions of the NCI study, the broadest ever conducted, are supported by many other scientific studies in the United States, Canada and Europe.

### Radiation Is Easily Detected

Radiation is a part of nature. Since the beginning of time, the Earth has been immersed in radiation, in the form of rays or particles. Although human senses can't detect it, radiation is easily detected with routine devices like photographic film and Geiger counters, as well as

thermoluminescent dosimeters (TLDs) worn by nuclear plant workers, medical workers and scientists. Other sophisticated instruments enable scientists to detect even the tiniest levels of radiation.

The average American receives 360 millirem of radiation each year. Three hundred millirem come from natural sources: the sun's rays, rocks, soil, building materials and other background sources. The other 60 millirem come from human activities and products, such as medical and dental X-rays and consumer products.

According to the National Council on Radiation Protection and Measurements, an independent scientific body chartered by Congress, the major sources of radiation exposure to the public are:

- radiation from nature, including radon, cosmic rays and even radiation in our bodies (267 millirem)
- radiation from medical procedures, including X-rays and nuclear medicine procedures (54 millirem)
- radiation from consumer products (9 millirem)
- other sources, such as fallout from past testing of nuclear weapons, and from

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the generation of electricity in nuclear, coal-fired and geothermal power plants.

The average American receives less than 0.1 millirem from nuclear power plants.

## Health Effects Studied Extensively

More is known about the potential health effects of exposure to radiation than any other physical or chemical hazard.

Radiation was discovered by Wilhelm Konrad Roentgen in 1895. Since then, an extensive body of knowledge has been collected, mainly from the exposure of individuals to occupational radiation; patients who received medical treatment using radiation; and individuals exposed to military uses of radiation, e.g., survivors of Hiroshima and Nagasaki.

National and international councils on radiation have performed scientific analyses of these data. Their analyses and recommendations are used by standard-setting organizations, including the federal government, to establish regulations for the control of man-made radiation.

**ICRP.** The International Commission on Radiological Protection, formed in 1928, provides worldwide guidance on radiation protection.

**NCRP.** The National Council on Radiation Protection and Measurements, the U.S. counterpart to the ICRP, was chartered by Congress in 1964.

**UNSCEAR.** The United Nations Scientific Committee on the Effects of Atomic Radiation was established in 1955.

**BEIR Committee.** The National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation, along with the committee's predecessors, has published a series of comprehensive and influential committee reports over the past 35 years.

The first standards for protecting workers and the general public from exposure to man-made radiation went into effect more than 60 years ago, and they have been updated periodically. In contrast to the study of radiation, the study of the health effects of pollution from chemicals is relatively new.

## Radiation Is Controlled And Strictly Regulated

The Nuclear Regulatory Commission (NRC) considers the recommendations of the NCRP in developing its regulations on radiation limits. The NRC limits the amount of radiation that workers or members of the public can be exposed to from all pathways—air, water and other means.

These regulations apply to operators of nuclear power plants and to industrial and medical facilities licensed to use radioactive materials. Specifications for X-ray machines are regulated by the Food and Drug Administration.

A member of the public's annual radiation exposure from

any NRC-licensed activity is limited to 100 millirem per year. Agency rules limit radiation doses to workers at nuclear plants to 5,000 millirem per year.

In practice, however, occupational exposures in the U.S. nuclear energy industry average below 500 millirem—less than 10 percent of the NRC limit—because of employers' adherence to the principle that all radiation exposures should be kept "as low as reasonably achievable." The average exposure for each worker in the U.S. nuclear energy industry in 2001 was 106 millirem, less than 3 percent of the NRC limit.

The U.S. Environmental Protection Agency develops federal radiation protection criteria, standards and policies. It studies measurement and control of radiation and provides technical assistance to states and other federal agencies, as well as directing a national surveillance program to measure radiation levels in the environment.

The EPA administers the radon abatement program and evaluates new and developing radiation technologies. It also establishes standards for disposal of radioactive waste and guidelines relating to the control of radiation exposure under the Atomic Energy Act, the Clean Air Act and other applicable legislation.

The Atomic Energy Act of 1954 gives states the authority

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to regulate radioactive materials from facilities, except nuclear power plants, within their jurisdictions. Thirty-one states have signed an agreement with the NRC to allow the agency to regulate the use of radioactive materials within their state. As a general rule, however, states have historically deferred to the federal government in determining safe radiation standards. Along with the Food and Drug Administration, some states regulate specifications for X-ray equipment.

### Studies Examine Risk of Low-Level Radiation

There is no consistent scientific evidence that people are harmed by exposure to radiation below 10,000 millirem.

Evidence of harm from exposure to radiation is almost entirely related to relatively short-term exposures to high doses, either the experience of people exposed during the bombings of Hiroshima and Nagasaki, or from medical uses of X-rays during the first half of this century.

While an increased incidence of some cancers has been observed following doses of radiation above 50,000 millirem, radiation is a relatively weak carcinogen—much weaker than many chemical carcinogens.

For more than 40 years, scientists have followed the health histories of more than 75,000 survivors of the Hiroshima and Nagasaki bombings who were exposed to more than 500 millirem. Of these, 6,000 died from some

form of cancer between 1950 and 1985—an excess of 350 cancer deaths above what would statistically be expected. More than 56 percent of the exposed populations being studied at Nagasaki and Hiroshima were still alive in 1990 (when the most recent cycle of mortality information was completed).

To ensure radiation standards are set conservatively, it has been customary to assume a linear relationship between radiation dose and its effect, an assumption maintained most recently by the National Academy of Sciences' BEIR V report in 1990. This means that scientists assume tiny doses of radiation have health effects in direct proportion to the known effects of large doses—even though no health effects have been directly observed at low doses.

Many scientists question the linear hypothesis because of the lack of evidence and the knowledge that many other agents that are harmful when taken in high doses have no effect at low doses. The BEIR V committee specifically pointed out that a threshold may exist below which radiation causes no harm. However, the linear—or “no threshold”—hypothesis is widely used to set conservative protection standards.

Using the linear hypothesis, if one million people were each

exposed to 100 millirem over one year—which is the NRC limit for public exposure—the

result would be an estimated 50 additional fatal cancers beyond the number normally expected from all other causes in that population during their lives. Instead of an expected 200,000 cancers, there might be 200,050.

**BEIR VII Committee.** The BEIR VII committee concluded in 1998 that epidemiologic studies of low-level radiation and cancer warrant a reassessment of health risks associated with low levels of radiation. Through a review of all relevant data and the development of appropriate risk models, experts will seek to determine what risks—if any—are posed by low levels of radiation. Publication of the BEIR VII report is expected in late 2003.

In 1998, the U.S. Department of Energy launched a 10-year research program that seeks to determine how human cells react to low-level radiation. Advances in molecular biology, including new data and technology from the Human Genome Project, have given researchers the tools they need to study the effects of low levels of radiation on human cells. The overarching goal of the program is to ensure that public health is protected.

*This fact sheet is also available at <http://www.nei.org>, where it is updated periodically.*